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ABSTRACT

This study investigated the extent of infant peripheral vision, specifically the extent of infants' constricted field, or tunnel vision. Thirteen infants, 2 to 5 months old, were tested using a psychophysical procedure to obtain contrast sensitivity thresholds at four retinal loci (-40, -15, +15, +40 deg.). Infants were placed in an infant bed in a dark room and presented first with a central fixation light, then a stimulus either to the right or left of the infant's fixation at 40 degrees eccentricity according to a random schedule. If the infant responded with directionally appropriate first eye movement occurring within three seconds of the termination of the stimulus, the intensity was decreased by .1 log unit steps until the response was no longer observable. Then the intensity was increased by .5 log unit steps until the response reappeared. Following this, the intensity was decreased using .1 log unit steps until the boundary was determined. The threshold values were taken as the minimum light tensity that would reliably elicit the response. Intensity changes were made independently for the left and right stimulus lights. Threshold measures for the 15 degree eccentricity were obtained in the same manner. Data indicated that infants are less sensitive to a peripherally presented point source than adults, the differences being greater in magnitude for the far targets than for the near targets. However, infants in this study were found to be capable of detecting targets farther in the periphery than previously realized, provided the target was sufficiently bright. The effectiveness of the methodology used is discussed. (SB)

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THE DEVELOPMENT OF PERIPHERAL VISION IN INFANTS

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Paper presented at the Southwestern Society for Research in Human Development, Dallas, Texas, March, 1978.

A number of investigators have suggested that infants and small children may have a constricted visual field or "tunnel vision." Among these is Piaget who posits a theory of centration, or the overestimation of what is fixated relative to that which appears peripherally. Mackworth and his colleagues have shown that interfixation distance, or small eye tracks demonstrated by young children also reveals a kind of tunnel vision. The absence of large saccades may mean that for a given fixation a child is incapable of obtaining information from the peripheral areas of the functional visual field.

While we have psychophysical evidence indicating that at the age of 6 years, the peripheral visual field approximates that of the adult, we have only meager evidence for the younger ages including infants and toddlers. The data that is available can be categorized into two methods. First, the confrontation technique, typically used by pediatric ophthalmologists, is where the E moves a source of light or small object from the periphery toward the midline and determines the point at which the infant becomes distracted and follows the object with his eyes. The stimuli are hand held and the E is usually eliciting the infant's attention by smiling broadly or talking animatedly. At best, the clinician has only a crude subjective estimate of visual field extent, and this estimate will vary with stimulus characteristics, speed of movement, luminance, and so forth, so that the result is rarely replicable even by the same E. Nevertheless, data using this method indicate that the visual field enlarges throughout the first year of life.

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The second method, typically used in experimental setting, employs a central fixation stimulus and a peripheral stimulus (usually a block or a light) which is mechanically moved along the midline to the periphery in steps of 5 or 10 deg. The response measure indicating the limits of the visual field is the ultimate failure of the infant to look at the stimulus when at the previous location the stimulus was detected successfully. The data from these experiments show that the infant has a variable field size depending upon certain stimulus characteristics (whether moving or stationary) and whether stimulus competition was eliminated. However, even under optimal conditions, newborns and young infants will orient toward targets only at 25 deg. or less from midline. (Adults have been shown to detect stimuli at 90 deg. from midline under optimal conditions.) Few infants were shown to respond to any stimulus under any conditions beyond 30 deg. eccentricity.

In each of these studies, the boundary between where the infant does or does not detect a peripheral stimulus is called the limit of the visual field. Yet, it is clear that the boundary will depend upon myriad stimulus and experimental conditions that enhance or discourage detection. The limits described are therefore arbitrarily linked to the parameters of the stimuli chosen.

The present experiment was designed to circumvent this problem by employing a psychophysical procedure to obtain contrast sensitivity thresholds for several retinal loci. With thresholds, one is better equipped to evaluate peripheral sensitivity since at some level of stimulus intensity a response will occur at any retinal position that does not have anatomical limitations. Because the criterion for detection remains the same, the changes in input required for detection can be interpreted as reflecting a change in sensitivity. By using thresholds, one can ask whether sensitivity across an infant's retina declines gradually or abruptly, whether the changes in sensitivity across the retina are similar in nature to the changes observed in adults, and whether there are different rates of development associated with different areas of the visual field.

The contrast required to detect a point source at four retinal loci (-40, -15, +15, +40 deg) was measured in 13 infants from 2 to 5 months of age and in adults by using a variation of the staircase method of limits. Thresholds were measured while the S was positioned in a specially constructed infant perimeter consisting mainly of a half cylinder arc of galvanized metal which was painted flat black and which could be lowered over an infant bed. Two point sources (2.9 cd) were attached to a neutral density filter wedge which could alter the intensity of the sources in .1 log unit steps from 0.0 log units to 7.9 log units (or by a factor of 100 million to 1) and could be placed tangentially to the perimater at any eccentricity in 5 deg steps along the horizontal meridian.

Each infant was brought into the laboratory and was allowed to dark adapt for 15 minutes. He was then placed supine in the infant bed and was aligned to the stimulus lights. Two observers monitored the infant's fixation and state. To begin each trial, the central fixation light was illuminated until the infant fixated it. Then a stimulus was presented either to the right or left of the infant's fixation at 40 deg eccentricity according to a random schedule. The response measure used was a directionally appropriate first eye movement which was scored if it occurred within 3 sec. of the termination of the stimulus. Both the stimuli and the central fixation light were blinked at a rate of 3 per sec. for a period of three seconds. If the infant responded correctly to the first stimulus intensity (1.0 log unit filter) the intensity was decreased by 1 log unit steps until the response was no longer observable. Then the intensity was increased by .5 log unit steps until the response reappeared. Following this, the intensity was decreased or increased using .1 log unit steps until the boundary was determined. The threshold values were taken as the minimum light intensity that would reliably (100%) elicit the response. Intensity changes were made independently for the left and right stimulus lights. Threshold measures for the 15 deg. eccentricity were obtained in the same manner.

(Slide 1) Log luminous intensity at threshold was plotted against eccentricity of the test stimulus for both infants and adults. All S's showed a lower threshold for near peripheral targets than for far peripheral targets. The difference in thresholds between infants and adults was 4.3 log units for the far targets and 3.6 log units for the near targets. For one infant, threshold values at 25 deg eccentricity were assessed in addition to the 40 and 15 deg eccentricities. (Slide 2) The threshold values show a function that is nicely symmetrical about the midline and is indicative of a gradual decrease in sensitivity with increasing target distance.

In order to assess age differences for the near and far targets, mean threshold values for the two distances were plotted as a function of age. (Slide 3) A regression line fitted to these scores indicates no significant differences in sensitivity with age.

(Slide 4) For far targets there was a correlation of -.56 between threshold and age. In other words, the older babies requires less intensity to detect the targets than did the younger babies. The slope of the regression is significantly different from zero.

In summary, the infants were found to be less sensitive to a peripherally presented point source than adults, the differences being greater in magnitude for the far targets than for the near targets. This result was interpreted as supporting the notion of narrowed vision in infants, but only if the constriction is defined in terms of a relative loss of sensitivity associated with the more extreme regions of the retina, and not a complete or absolute loss of sensitivity beyond some derived limit. However, all infants in this study were shown to be capable of detecting targets farther in the periphery than was previously realized, provided that the target was sufficiently bright.

Further, these data provide support for a notion of differential rates of growth for the far and the near periphery between 2 and 5 months of age.

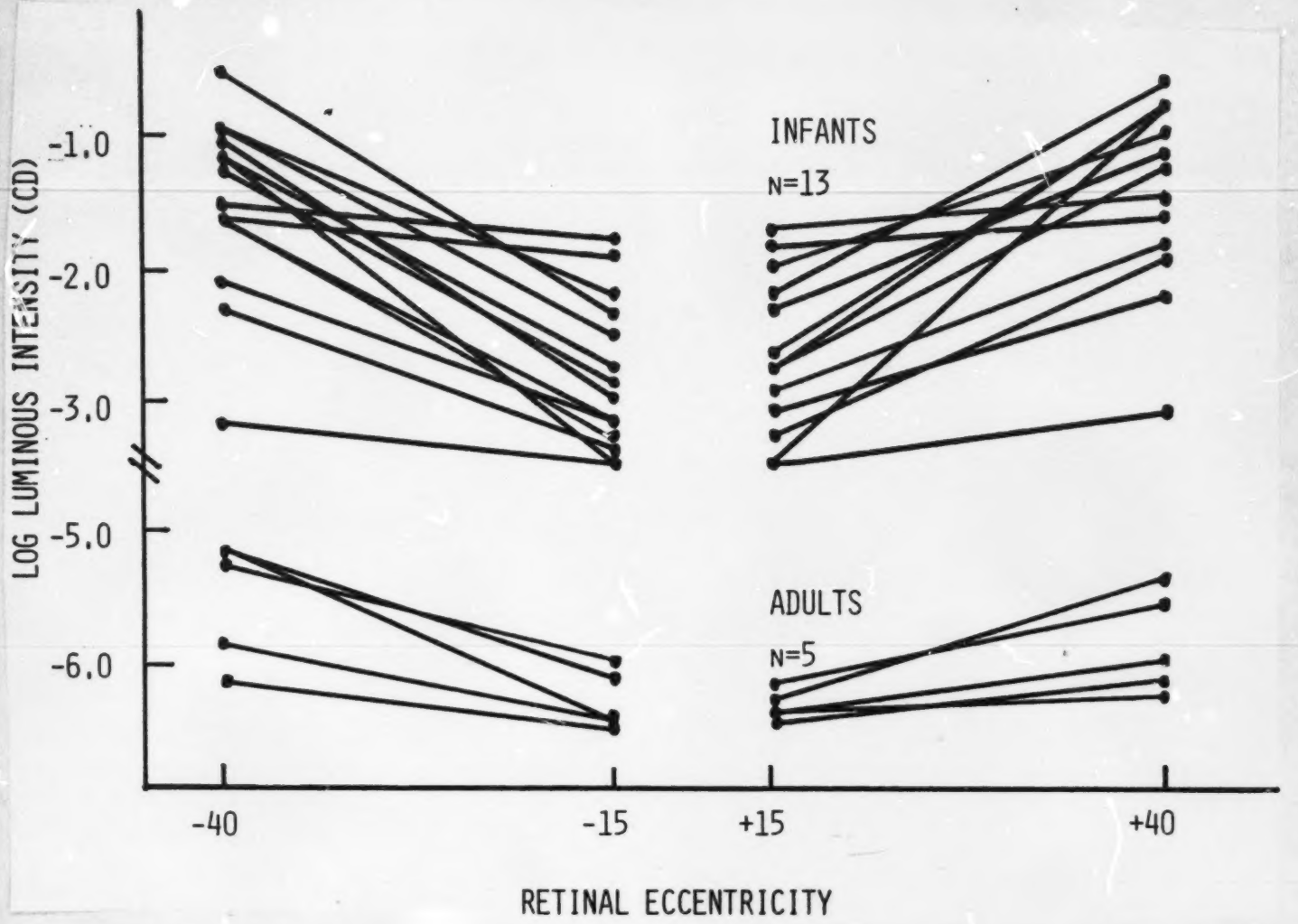
Several comments should be made on the effectiveness of this methodology

for assessing visual functioning. The use of the staircase method of limits was innovative in that it insured a directionally appropriate ocular shift at any retinal location. Complete visual fields can therefore be mapped even for the very young infants.

Also, in this method, the infant is asked to localize a target presented peripherally. As long as the stimulus intensity was above the infant's threshold, the infant repeatedly located the target even after a very large number of trials. In the present study, the derivation of each threshold to within .1 log unit required the infant to respond about 20 times. However, even when the infants were required by us to locate the stimulus over 40 times at one stimulus intensity, there was no habituation to the stimuli. This is an improvement over confrontation technique which is effective only for about 30-60 seconds. This lack of habituation in a localization task may relate to a concept of multiple modes of processing visual information or the "two visual systems" hypothesis. In this view, there are at least two relatively independent visual systems with complimentary functions. The ambient system which is primarily represented by retino-mesencephalic structure is responsible for orienting to and locating targets. The focal system, or retino-telencephalic one, processes patterns or identifies these targets. The localization of peripheral targets may then be mediated subcortically, in which case habituation would not be expected to occur. Further, localization of peripheral targets would not be expected to be altered by attentional or motivational factors.

Finally, the reliability of these thresholds is within .1 log unit for different observers on different days. While the data are incomplete, it would seem that the threshold measures are relatively robust.

To conclude, this methodology may be useful not only to the E who attempts to understand the mechanisms underlying the development of the visual system, but also to the clinician who attempts to unveil visual deficits early in the life span, particularly in cases of retinal degeneration or infant glaucoma.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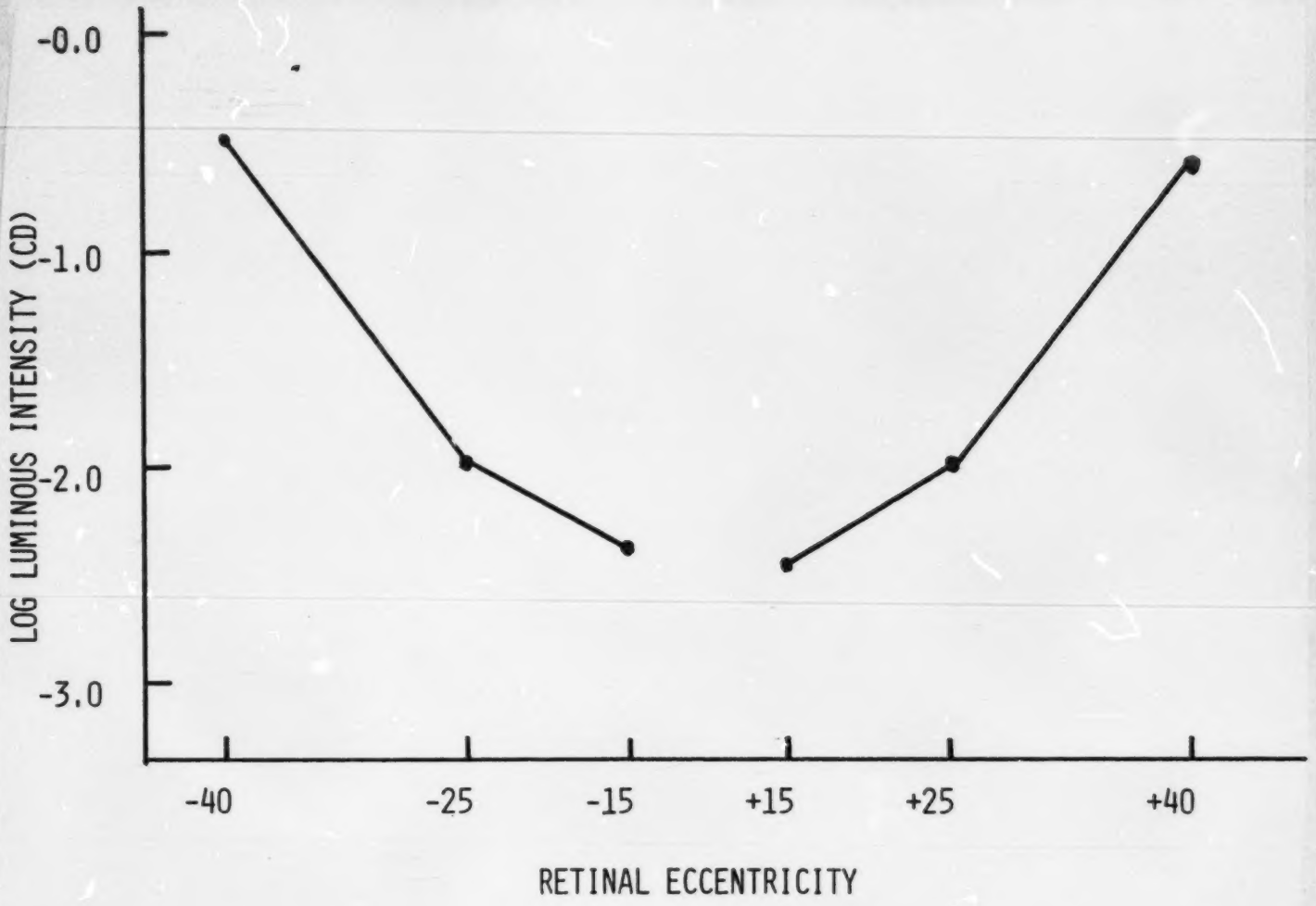
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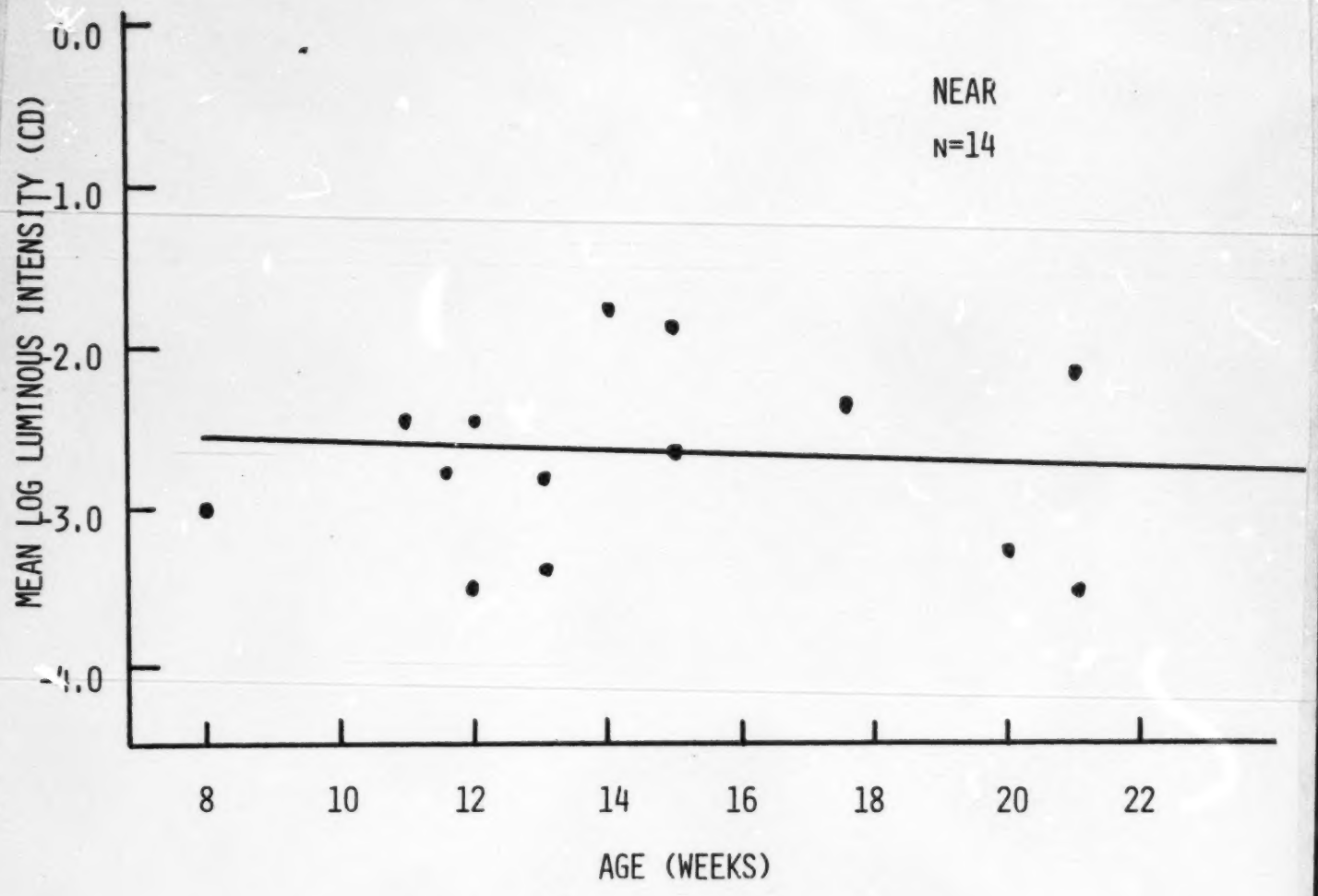
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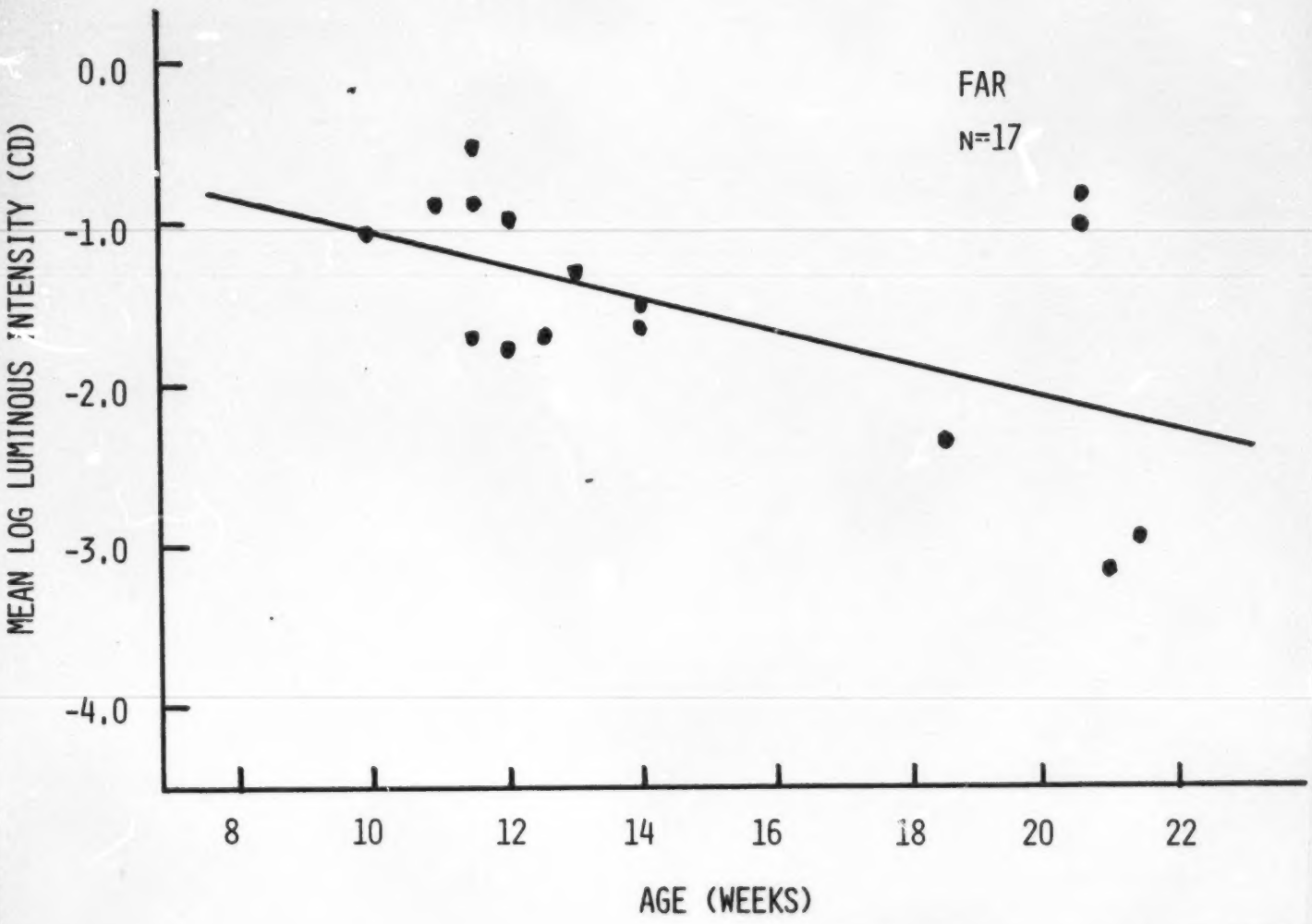
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AGE (WEEKS)